PB-215 092

SPECIAL STUDY OF SEWAGE TREATMENT FACILITIES AT MAMMOTH CAVE NATIONAL PARK, KENTUCKY

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

July 1956

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 215 092

SPECIAL STUDY

of

SEWAGE TREATMENT FACILITIES

at

MAMMOTH CAVE NATIONAL PARK, KENTUCKY

Prepared For

The National Park Service

by

U. S. Department of
Health, Education, and Welfare
Public Health Service

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

Region III, Charlottesville, Virginia

Reproduced from
best available copy.

June-July 1953

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

SPECIAL STUDY OF SEWAGE TREATMENT FACILITIES
MAMMOTH CAVE NATIONAL PARK, KENTUCKY

TABLE OF CONTENTS

Quantity and Characteristics of the Sewage.

Analysis of Sewage Treatment Plant Performance.

Summary

APPENDIX

Figure 1 - Relationship of Water Pumped to Sewage Flow.

Table 1 - Water Plant Pumping Record.

Figure 2 - Hourly Flow Variation.

Table 2 - Hourly Flow Record at Sewage Plant.

Table 3 - Water Use for Period June 28-July 19.

Figure 3 - Hourly BOD Variation

Table 4 - Analytical Data BOD.

Figure 4 - Histogram of Suspended Solids.

Table 5 - Analytical Data Total Solids.

Table 6 - Analytical Data Suspended Solids.

Table 7 - Analytical Data Settleable Solids.

Chemical Analysis of Finished Water.

This is a report of a special study of the sewage treatment facilities serving Mammoth Cave National Park, made at the request of the National Park Service. The objectives of this study were to determine, 1) the quantity and characteristics of the sewage produced in this heavily used National Park and, 2) the efficiency of the units of the sewage treatment plant.

The study was carried out as a cooperative undertaking by Public Health Service Region III, Charlottesville, Va., and the Sanitary Engineering Center of Cincinnati. Field engineering personnel for the conduct of the study were supplied by the Regional Office, and a mobile laboratory, together with a chemist and an aide, was supplied from Cincinnati. Technical consultation was also furnished by Sanitary Engineering Center. The Kentucky Stream Pollution Control Commission advised with the Public Health Service in the planning of the Study and supplied a vehicle and boat which were used in the sampling program. The period of field study was from June 28 to July 14, 1956. This period was deliberately chosen in order to include the July 4 holiday period at which time all National Parks usually experience one of their peak population loads.

All of the areas administered by the National Park Service are receiving an annual increase in visitation and use. As a result, many of these areas need enlarged sewage collection and treatment facilities now or will need them in the near future. Under the present National Park Service program, known as "Mission 66," plans are being made to provide these needed facilities. There is very little, if any, data in the

literature relating to the characteristics of sewage produced in strictly recreational areas. The results of this study should be useful in determining the adequacy of the large sewage treatment plants as well as the preparation of plans and construction of this type of facility by the National Park Service.

Quantity and Characteristic of the Sewage

In order to establish relationships of per capita water usage for the various areas within the Park, records were obtained of the water supply pumpage and the metered water use in these various areas.

The water supply pumping records (Table 1) are kept daily and are based on the rated pump capacity and hours the pump operated each day. One factor which was not determined was the relative elevation of the two 200,000 gallon storage reservoirs at the start and end of the survey. However, this factor should be self-compensating for the period of survey because the water pumpage closely parallels the flow received at the sewage plant (Figure 1). The metered water usage, available from seven locations, was obtained for June 28 to July 19. The meters are installed at locations as described in Table 3. The flow of sewage to the treatment plant was measured by use of a 60° V-notch weir with a water level recorder (Table 2). The sewer system (approximately two miles in length) accounts for little, if any, infiltration. Even though several heavy rains occurred during the survey, no increase in flow reaching the plant was noted. The relationship of the metered water use to that as gaged at the sewage plant, gave an excellent correlation, and for this reason, per capita water consumption data is tabulated. There are seven (7) residences and also one comfort station in the Cave served

by the water system but are equipped with individual sewage disposal systems.

Table 3 indicates the percapita water use of the various areas. The variation of water use from 124 gpcd to 36 gpcd is reflected primarily in the type of accommodations. The figure of 124 gpcd, for hotel and cabins equipped with individual bath facilities, is somewhat higher than actual usage per guest because of water supplied for air-conditioning, and the use of the public restroom facilities in the hotel by transients.

The average flow of sewage during this study was 18.7 gallons per minute or 26,900 gallons per day. The peak flow of 23.1 gallons per minute or 33,200 gallons per day was received on Saturday following the fourth of July holiday. It is of interest to note that during the 18 hour period of 6:00 A.M. to 12:00 midnight of an average day in this large recreational area, that the average sewage flow was 22.3 gallons per minute or 24,000 gallons which is 90% of the average daily flow.

The method of obtaining the sewage samples for analysis was to composite hourly samples in relationship to the sewage flow as recorded for 16-hours per day, starting at 6:00 A.M. The only exception is three sampling days as noted; two for a 24-hour period and one for a 13-hour period. Two days during the survey, the 5th and 10th, samples could not be obtained because the road to the plant was impassible due to heavy rains.

The raw sewage had some oxygen content varying from a minimum of zero to a maximum of 3.4, with an average of 1.3 for 125 determinations.

There is apparently no correlation of dissolved oxygen content to flow or time of day.

The BOD of the raw sewage had an average value of 236 ppm., with a range of 141-292 ppm (Table 4). A plot of the hourly BOD collected on July 11, is shown in Figure 3. As would be expected, because of the small quantities involved, an irregular curve is obtained from the raw sewage BOD data. Analysis of total and suspended solids (Tables 5 and 6) were made on each of the composite samples and volatile and fixed solids content determined for each. The range of suspended solids was 122 to 306, with an average of 234 ppm (Figure 4).

Other characteristics of the raw sewage measured were pH, chlorides, temperature, and alkalinity. The pH and temperature were relatively constant, with a range of 7.3 to 7.7 and 23°C plus or minus 1°C respectively. The chlorides had a range of 24 to 60, with an average of 40 ppm. The alkalinity has a range of 250 to 314, with an average of 292 ppm. The pH of the water supply was determined to be 7.3, the alkalinity was 76 ppm, and the chlorides 1.5 ppm. (See "chemical analysis finished water" in appendix for additional data). Therefore, the only appreciable change is the addition of chlorides and alkalinity by the waste, which are in normal amounts.

Reproduced from best available copy.

Analyses of Sewage Treatment Plant Performance

The sewage treatment plant consists of two Imhoff tanks, sludge beds and a trickling filter. One very small Imhoff tank built around 1935, can be used for low winter flow and a larger tank, built around 1939, for the higher summer flow. Each Imhoff tank has a sludge drying

bed. For secondary treatment, a standard rate trickling filter equipped with a rotary distributor is employed with no secondary sedimentation.

The effect of treatment on BOD (Table 4) shows an average removal by the large Imhoff tank of 46 per cent, and an overall plant efficiency of 90 per cent. The overall efficiency is reduced somewhat by the lack of secondary sedimentation, as indicated on July 2nd when the filter was sluffing. However, since the effect on the receiving stream, Green River, is negligible and the fact that a high type effluent was produced, no reasonable justification for secondary sedimentation can be offered.

The efficiency of treatment on suspended solids (Figure 4 and Table 6) shows removal by the Imhoff tank of 65 per cent, and an 86 per cent overall removal. The dissolved oxygen content of the filter effluent varied from a minimum of 2.9 to a maximum value of 6.2, with an average value of 4.6 for 12 determinations. Dissolved oxygen in the effluent of the Imhoff tank was zero for all determinations. Evidence of excellent aerobic conditions in the filter, besides the BOD reduction and DO, was the reduction of alkalinity through the filter indicating evolution of CO_2 without appreciable change of the pH. The pH, chlorides, and dissolved solids remain relatively constant through the treatment plant as would be expected.

It should be pointed out that this plant receives a very minimum of maintenance, and only one time during the sampling period was any attention given to the treatment plant.

The settling chamber of the Imhoff tank contains 12,500 gallons, and at the 18 hour average flow of 22.3 gallons per minute, this chamber

has a retention time of 9 hours. The present design practice is for a 2 hour detention which indicates that this settling chamber has capacity for a large increase of the sewage flow.

The sludge compartment contains 1,958 cubic feet. Based on a design of 8.4 cubic feet per pound solids added per day and the suspended solid content of 234 ppm with 65 per cent removal in this tank, this sludge compartment should contain 2,856 cubic feet. Considering that 90 per cent of the travel into this National Park is in a five months period, it appears reasonable to state that approximately one-half of the digestion capacity normally needed would be adequate for this particular plant. Thus, approximately 1,500 cubic feet are needed and this sludge digestion compartment has capacity for a small increase in loading.

The sludge bed contains 1,366 square feet which appears to be adequate at the present time considering the type of sewage flow received throughout the year.

The trickling filter contains 211 cubic yards or 0.31 acre feet of rock. 52 per cent of the raw sewage BOD of 236 ppm or 23 pounds per day was being discharged onto the filter. This produced a loading of 260 pounds of BOD per acre foot, which is approximately 50 per cent of the present design loading of about 500 BOD per acre foot. The filter has a surface area of 1,075 square feet and the average daily flow produced a hydraulic loading of 1.1 million gallons per acre per day. This is below the present design loading ranging from 2 to 4 million gallons per acre per day.

This filter is equipped with a 4" siphon and a two-arm rotary distributor. The manufacturer has furnished information that this equipment was designed for a flow of 50 gallons per minute at the high water level at the dosing tank. It was noted during this survey that it was not unusual for this siphon to discharge continuously for several hours, which indicates that the discharge rate of this equipment was restricted to a flow of probably 30 to 35 gallons per minute. During a period of low flow this filter should be bypassed and all piping in the siphon and rotary distributor should be flushed or rodded so as to remove any obstructions that are causing the restriction in discharge rate.

SUMMARY AND CONCLUSION

Following is a brief summary of the conclusions that are made as a result of the survey of the sewage treatment facilities serving Mammoth Cave National Park:

(1) The characteristics of the raw sewage, particularly the BOD of 236 ppm and the suspended solids of 234 ppm, indicate that the sewage produced in this National Park is very similar to a domestic type sewage of a municipality.

(2) There is a very small amount, if any, of infiltration into the sewer collection system.

(3) The sewage treatment plant is not loaded to capacity. As the loading in this plant increases in the future, the sludge digestion compartment of the Imhoff tank will be the first portion of the plant that will be over-loaded. When this happens, serious consideration should be given to use of the small Imhoff as a secondary sludge digestor.

(4) The piping in the siphon and rotary distributor should be cleared of any obstructions so that this equipment can operate at its designed capacity.

(5) The various plant units are in good physical condition and no deterioration of the filter rock was in evidence.

(6) The sewage treatment plant is removing 90 per cent of the BOD and is producing a very satisfactory effluent.

(7) The percapita water consumption data, as shown in Table 3, should be useful in planning for the construction of water and sewage facilities in other National Park Service jurisdictions.

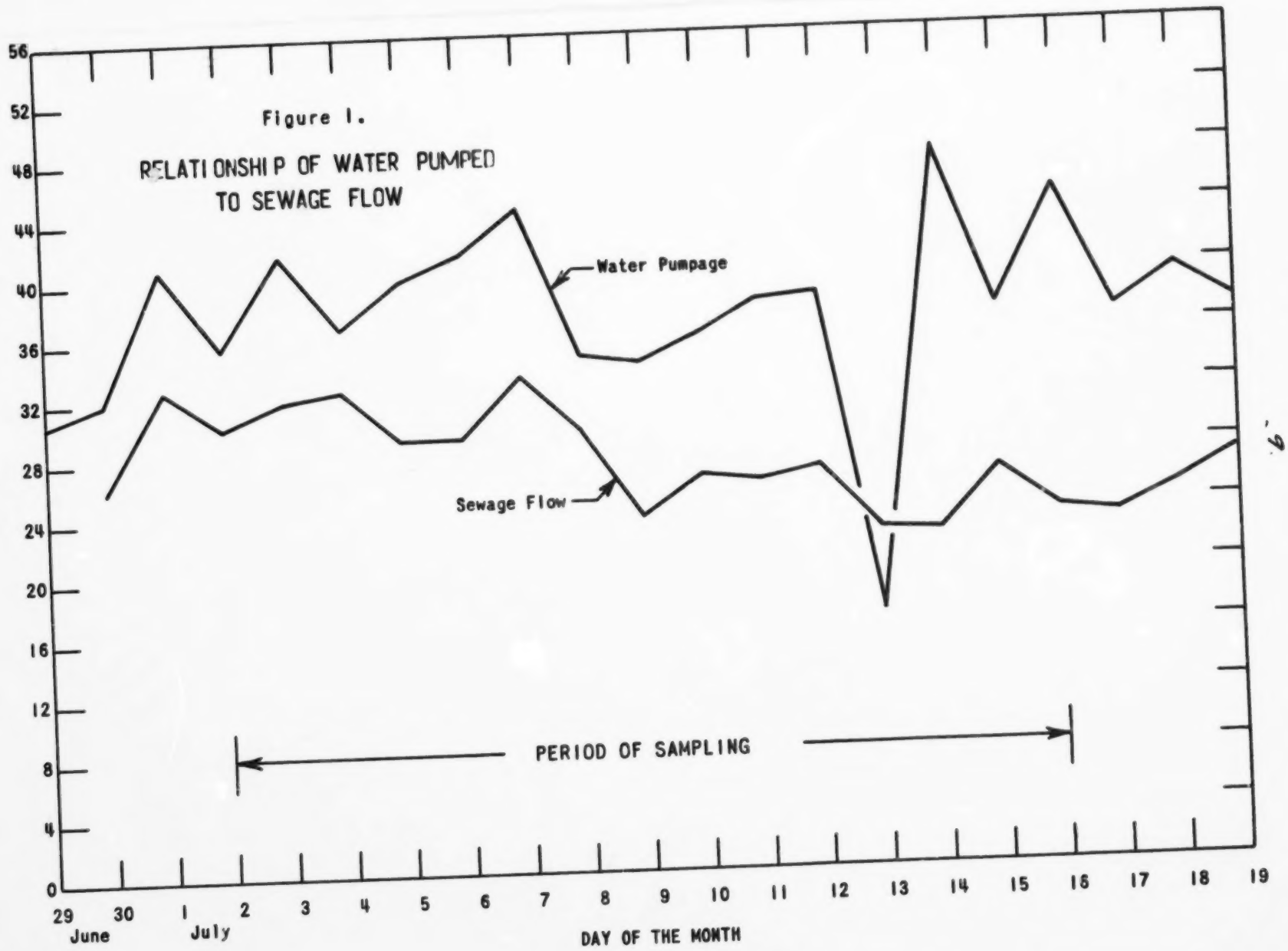
Figure 1.
RELATIONSHIP OF WATER PUMPED TO SEWAGE FLOW
Water Pumpage
Sewage Flow
PERIOD OF SAMPLING
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
June
July
DAY OF THE MONTH

TABLE 1

WATER PLANT PUMPING RECORD

in GPD

DATE	STATION #1	STATION #2	TOTAL
June 28	19,200	9,000	28,200
29	19,200	11,400	30,600
30	20,100	11,800	31,900
July 1	24,600	16,200	40,800
2	20,400	15,000	35,400
3	26,400	15,300	41,700
4	21,600	15,000	36,600
5	22,800	17,000	39,800
6	26,400	15,000	41,400
7	27,600	16,800	44,400
8	21,000	13,500	34,500
9	18,000	15,900	33,900
10	21,600	14,100	35,700
11	22,200	15,900	38,100
12	20,400	18,000	38,400
13	-	16,800	16,800
14	34,200	13,800	48,000
15	20,400	16,800	37,200
16	45,000	-	45,000
17	15,600	21,300	36,900
18	26,400	13,200	39,600
19	22,800	14,400	37,200
	495,900	316,200	812,100

Average - 36,900 gallons per day.

Figure 2.

HOURLY SEWAGE FLOW VARIATION

Max. 33,200 Gal.
Avg. 26,900 Gal.

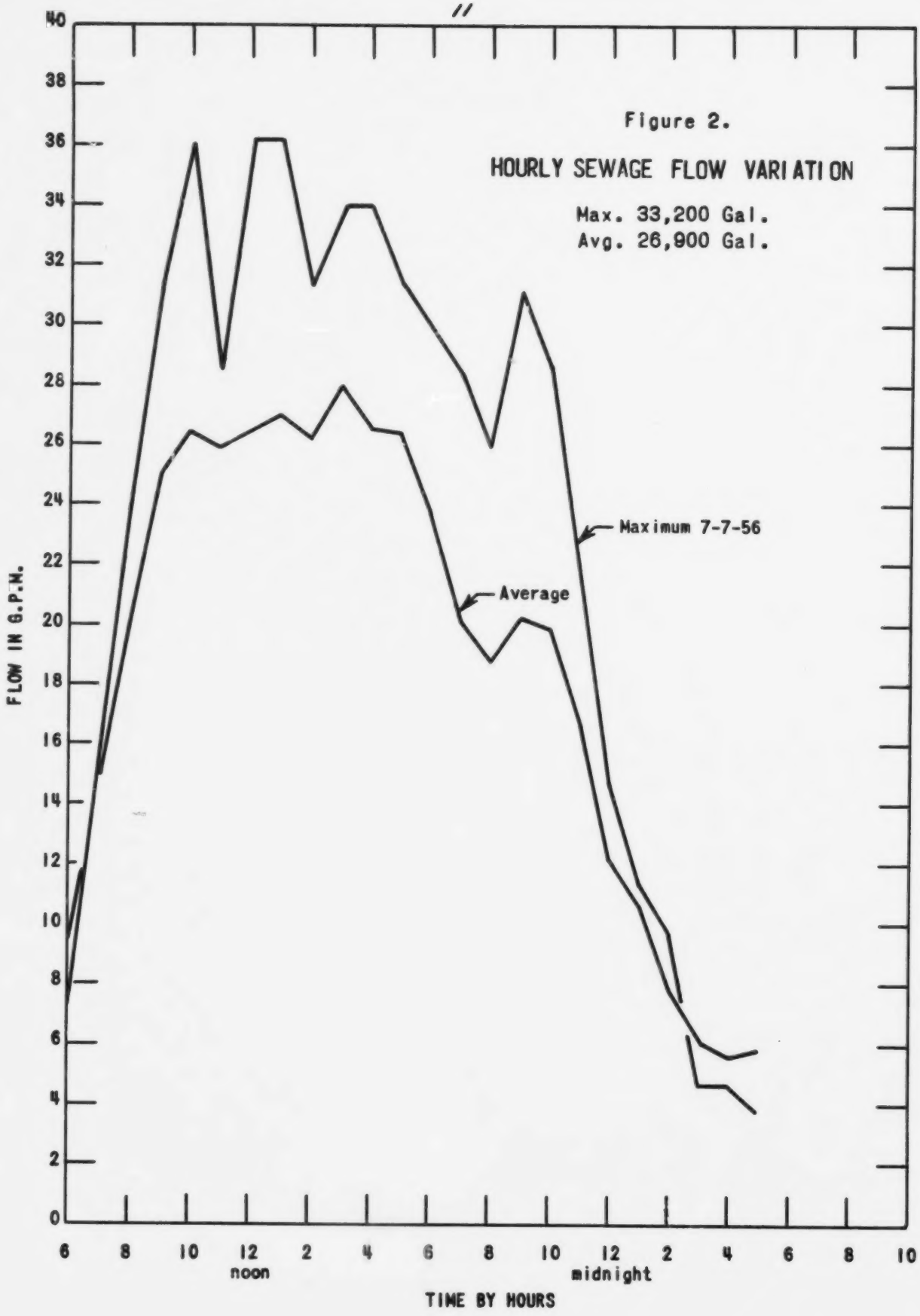

TABLE 2

HOURLY FLOW RECORD - TAKEN AT EFFLUENT OF IMHOFF TANK WITH 60°V-NOTCH WEIR AND WATER STAGE RECORDER

Time	6-29	6-30	7-1	7-2	7-3	7-4	7-5	7-6	7-7	7-8	7-9	7-10	7-11	7-12	7-13
6 AM		8.6	9.7	9.7	7.5	17.8	14.5	7.5	7.5	9.7	9.7	5.5	9.7	9.7	9.7
7		17.8	17.8	19.7	16.5	17.8	12.8	14.5	16.0	12.8	16.0	16.0	14.5	16.0	19.7
8		17.8	21.5	28.5	19.7	21.5	14.5	21.5	23.6	17.8	19.7	21.5	17.8	23.6	21.5
9		21.5	34.0	31.2	31.2	25.9	23.6	23.6	31.2	25.9	19.7	23.6	23.6	28.5	21.5
10		21.5	36.2	34.0	28.5	28.5	28.5	25.9	36.2	21.5	21.5	21.5	25.9	28.5	21.5
11		21.5	34.0	31.2	28.5	34.0	25.9	25.9	28.5	25.9	28.5	21.5	19.7	25.9	19.7
12 Noon		21.5	34.0	31.2	25.9	34.0	25.9	31.2	36.2	36.2	31.2	21.5	21.5	23.6	19.7
1		19.7	34.0	31.2	25.9	34.0	31.2	28.5	36.2	40.0	34.0	23.6	21.5	28.5	21.5
2		25.9	34.0	28.5	28.5	36.2	31.2	28.5	31.2	31.2	28.5	23.6	21.5	21.5	17.8
3		31.2	34.0	31.2	31.2	34.0	28.5	36.2	34.0	31.2	28.5	23.6	23.6	21.5	21.5
4		17.8	34.0	28.5	36.2	34.0	28.5	31.2	34.0	31.2	23.6	28.5	25.9	21.5	19.7
5		28.5	31.2	23.6	34.0	31.2	25.9	28.5	31.2	28.5	21.5	28.5	28.5	19.7	16.0
6	14.5	34.0	31.2	25.9	31.2	25.9	28.5	28.5	25.9	25.9	23.6	25.9	23.6	17.8	16.0
7	16.0	23.6	25.9	23.6	25.9	19.7	28.5	21.5	28.5	23.6	14.5	21.5	21.5	14.5	12.8
8	17.8	17.8	21.5	21.5	21.5	19.7	23.6	21.5	25.9	21.5	12.8	19.7	23.6	17.8	17.8
9	17.8	19.7	25.9	23.6	28.5	19.7	19.7	21.5	31.2	21.5	14.5	19.7	25.9	19.7	23.6
10	14.5	19.7	25.9	23.6	31.2	17.8	19.7	21.5	28.5	21.5	12.8	19.7	19.7	17.8	23.6
11	13.6	25.9	19.7	21.5	23.6	19.7	19.7	17.8	21.5	17.8	7.5	16.0	12.8	14.5	16.0
12 Midnight	13.6	17.8	11.3	11.3	14.5	16.0	16.0	16.0	14.5	14.5	7.5	12.8	11.3	14.5	9.7
1 AM	8.6	7.5	7.5	7.5	7.5	12.8	12.8	12.8	11.3	12.8	6.4	9.7	11.3	12.8	5.5
2	6.4	4.6	5.5	5.5	5.5	11.3	9.7	9.7	9.7	6.4	3.8	9.1	9.7	12.8	4.6
3	4.6	3.2	3.8	3.8	9.7	9.7	5.5	4.6	4.6	5.5	3.2	8.6	5.5	12.8	4.6
4	3.8	3.2	4.6	4.6	7.5	8.6	3.8	4.6	4.6	4.6	3.8	8.6	5.5	11.3	4.6
5	3.8	3.2	5.5	3.8	9.7	9.7	3.8	3.8	3.8	4.6	2.6	8.6	5.5	11.3	5.5
Total		433.5	542.7	504.7	529.9	539.5	482.3	486.8	555.8	492.1	395.4	439.4	429.7	446.1	374.1
Avg. Flow in GPM		18.0	22.6	21.0	22.1	22.5	20.1	20.3	23.1	20.5	16.4	18.3	17.9	18.6	15.6
Flow in GPD		25,900	32,600	30,200	31,800	32,400	29,000	29,200	33,200	29,500	23,700	26,400	25,800	26,800	22,500

TABLE 2 (Con't.)

HOURLY FLOW RECORD - TAKEN AT EFFLUENT OF IMHOFF TANK WITH 60°V-NOTCH WEIR AND WATER STAGE RECORDER

Time	7-14	7-15	7-16	7-17	7-18	7-19	7-20	7-21	Average
6 AM	8.6	7.5	16.0	3.8	6.4	6.4	7.5	11.3	9.3
7	12.8	17.8	19.7	8.6	8.6	14.5	14.5	12.8	15.2
8	19.7	19.7	28.5	14.5	14.5	17.8	14.5	16.0	19.8
9	25.9	23.6	23.6	21.5	16.0	25.9	34.0	16.0	25.0
10	23.6	21.5	25.9	21.5	31.2	28.5	31.2	19.7	26.5
11	19.7	21.5	17.8	25.9	36.2	31.2	25.9	21.5	25.9
12 Noon	17.8	25.9	17.8	19.7	28.5	31.2	25.9	23.6	26.4
1	17.8	23.6	19.7	23.6	28.5	23.6	25.9	21.5	27.0
2	21.5	28.5	17.8	23.6	25.9	25.9	21.5	23.6	26.2
3	36.2	31.2	19.7	21.5	25.9	31.2	21.5	19.7	26.0
4	23.6	28.5	28.5	19.7	28.5	31.2	21.5	17.8	26.5
5	23.6	23.6	17.8	19.7	25.9	28.5	21.5	21.5	25.4
6	12.8	19.7	17.8	16.0	25.9	21.5	25.9	14.5	23.6
7	17.8	14.5	21.5	14.5	16.0	16.0	21.5	14.5	20.1
8	14.5	14.5	19.7	12.8	16.0	19.7	16.0	11.3	18.7
9	17.8	17.8	14.5	12.8	23.6	25.9	19.7	8.6	20.2
10	14.5	16.0	17.8	12.8	21.5	25.9	14.5	11.3	19.9
11	7.5	8.6	14.5	12.8	9.7	19.7	8.6	17.8	16.5
12 Midnight	6.4	7.5	9.7	21.5	5.5	8.6	9.7	11.3	12.2
1 AM	3.8	12.8	6.4	31.2	4.6	7.5	8.6	19.7	10.5
2	3.8	16.0	5.5	11.3	5.5	4.6	6.4	9.7	7.8
3	3.8	18.6	5.5	7.5	3.8	3.2	4.6	4.6	6.1
4	6.4	9.7	4.6	5.5	5.5	3.8	3.8	4.6	5.6
5	9.7	12.8	3.8	4.6	3.8	3.2	4.6	4.6	5.8
Total	369.6	441.5	394.4	386.9	417.5	455.5	409.3	357.5	448.2
Avg. Flow in GPM	15.4	18.4	16.4	16.1	17.4	19.0	17.0	14.9	16.7
Flow in GPD	22,200	26,500	23,700	23,200	25,000	27,300	24,600	21,400	26,900

TABLE 3

WATER USE FOR PERIOD JUNE 28, THROUGH JULY 19, 1956

1. Total Water Pumped - 812,100 gallons.

2. Metered Water Record:

Meter Location	Water Used	No. of Units	Unit Water Use
Service Station	13,000	- - -	620 GPD
Multi Cabin Unit	40,940	610 people	67 GPCD
Dallas Huts	75,090	926 people	81 GPCD
Hotel Kitchen	82,230	23,177 meals	3.6 Gal/Meal Served
Hotel & Cabins	282,200	2270 people	124 GPCD
Cabin (area) #1	85,000	2351 people	36 GPCD
	578,460		

Total Water Metered, 578,460

Total Sewage Flow, 574,100

3. Water Not Metered:

Total Pumped, 812,100 gallons

Total Metered, 578,460 gallons

Unmetered, 233,640 Gallons

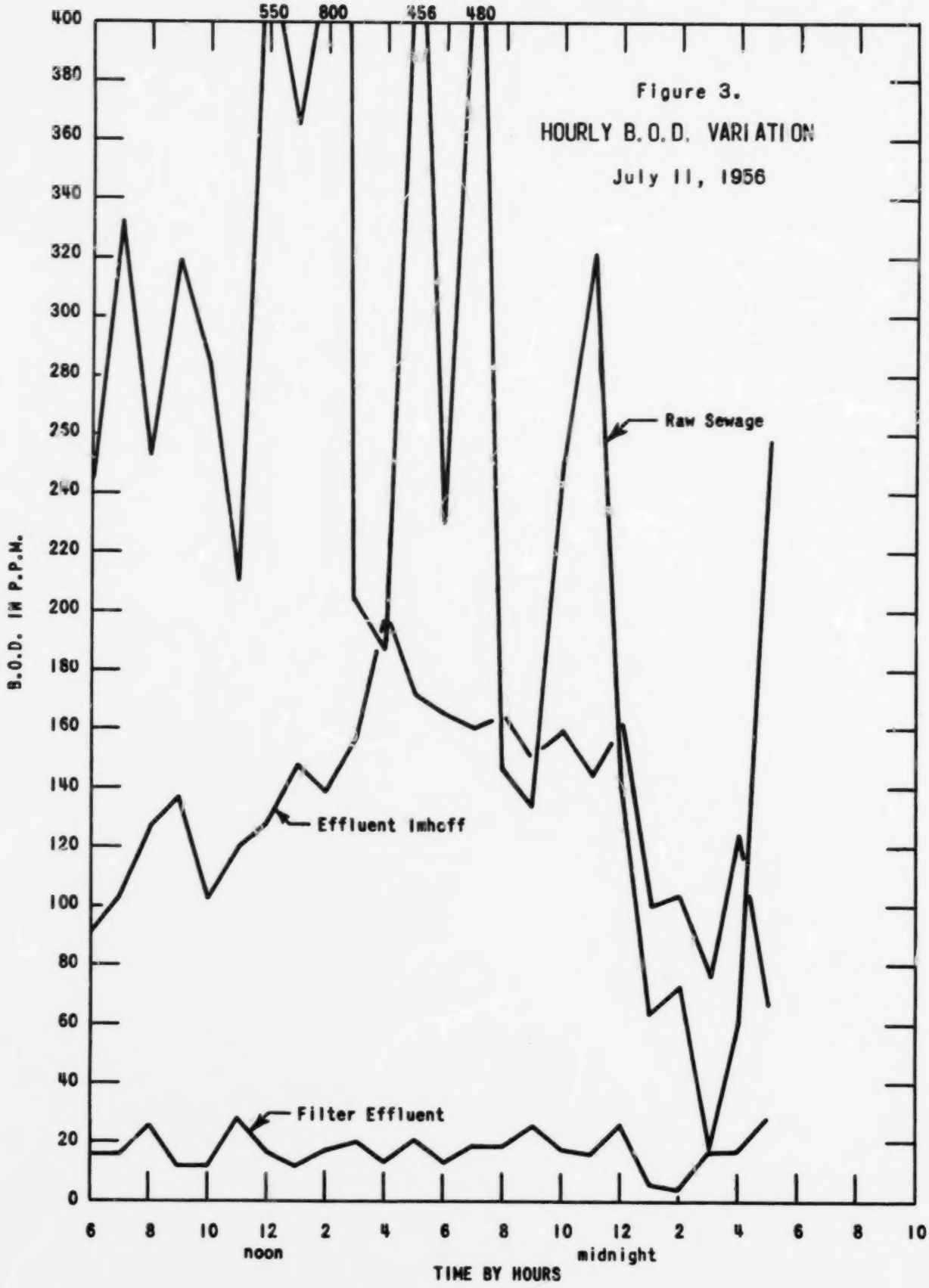

Figure 3.

HOURLY B.O.D. VARIATION

July 11, 1956

TABLE 4

ANALYTICAL DATA B.O.D.

Date		RAW Flow gpd	RAW B.O.D. ppm	RAW B.O.D. in Lbs.	IMHOFF B.O.D. ppm	IMHOFF B.O.D. in Lbs.	FILTER B.O.D. ppm	FILTER B.O.D. in Lbs.
7-2		25,300	227	47.9	150	31.6	63	13.3
3		25,400	236	50.0	141	29.9	21	4.4
4		25,400	297	62.9	159	33.7	25	5.3
5	(A)	19,200	220	35.2	124	19.8	19.4	3.1
6		23,600	-		-	-	-	
7		28,400	275	64.1	132	31.3	26	6.2
8		24,100	279	56.1	156	31.4	20	4.0
9		20,400	299	50.9	152	25.9	13.7	2.3
10		20,700	-	-	-	-		
11	(B)	25,800	266	57.2	133	28.6	17.2	6.1
12		20,100	141	23.6	78	13.1	13	2.2
13		18,400	223	34.2	103	15.8	19.7	3.0
14		18,600	167	25.9	72	11.2	19	2.9
15		20,100	227	38.0	113	18.9	24	4.0
16	(B)	19,400	205	33.2	120	20.7	17.4	2.8
Average		22,300	236	44.5	122	24.0	22.7	4.58

Average Percent Removed by Imhoff Tank 48%
Average Overall Efficiency 90%

(A) - 13 Hour Composite
(B) - 24 Hour Composite

Figure 4.

HISTOGRAMS OF SUSPENDED SOLIDS

July 2-13 1956

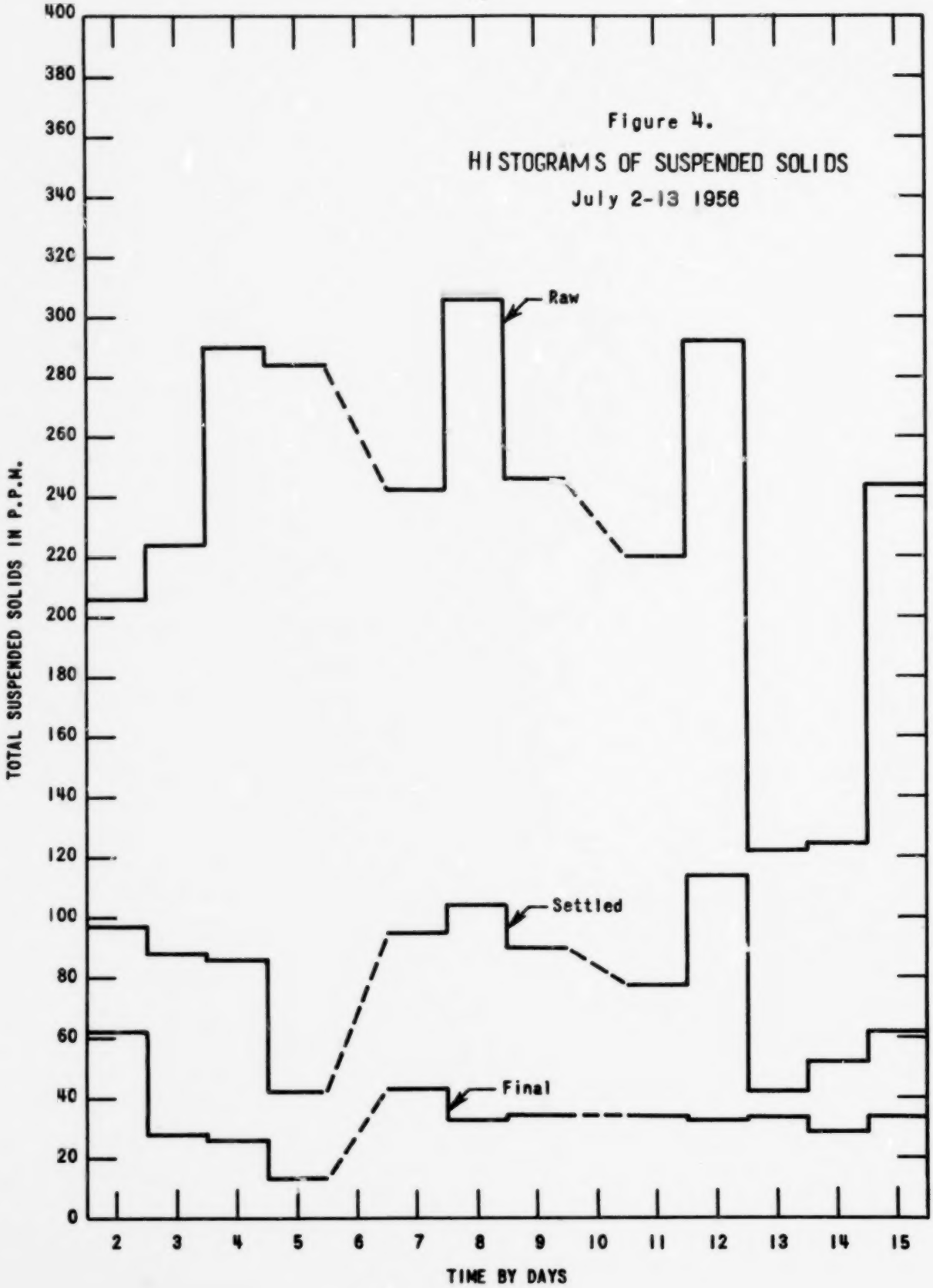

TABLE 5
ANALYTICAL DATA

Total Solids ppm

Date 1956 July	Raw Total	Raw Volatile	Raw Fixed	Imhoff Total	Imhoff Volatile	Imhoff Fixed	Filter Total	Filter Volatile	Filter Fixed
2	607			545			598		
		352			286			322	
		255			259			276	
3	501			476			521		
		361			246			274	
		240			230			247	
4	681			501			506		
		405			241			243	
		276			260			263	
5 (A)	603			445			489		
		318			187			225	
		285			256			264	
7	697			616			524		
		437			264			260	
		260			352			264	
8	775			540			565		
		533			330			340	
		242			210			225	
9	610			482			502		
		380			236			245	
		230			254			257	
11 (B)	672			466			523		
		382			200			259	
		290			266			264	
12	741			500			507		
		456			362			224	
		285			238			283	
13	639			482			521		
		347			219			254	
		292			263			267	
14	500			430			477		
		223			170			217	
		277			260			260	
15	777			549			477		
		496			291			208	
		281			258			269	
16 (B)	729			499			455		
		409			225			323	
		320			274			132	

(A) - 13 Hour Composite
(B) - 24 Hour Composite

TABLE 6
ANALYTICAL DATA

Suspended Solids ppm

Date 1956 July	Raw Total	Raw Volatile	Raw Fixed	Imhoff Total	Imhoff Volatile	Imhoff Fixed	Filter Total	Filter Volatile	Filter Fixed
2	206	176	30	97	93	4	62	57	5
3	224	210	14	88	88	0	28	28	0
4	290	266	24	66	66	0	26	26	0
5 (A)	284	258	26	42	42	0	13	13	0
7	242	226	16	95	91	4	43	43	0
8	306	306	0	104	90	14	33	27	6
9	246	218	28	90	90	0	34	34	0
11 (B)	220	220	0	78	78	0	34	34	0
12	292	266	26	114	102	12	33	30	3
13	122	98	24	48	40	8	34	27	7
14	124	106	18	52	42	10	29	25	4
15	244	230	14	62	54	8	34	28	6
16 (B)	240	198	42	112	100	12	26	21	5

(A) - 13 Hour Composite
(B) - 24 Hour Composite

TABLE 7
ANALYTICAL DATA

Settleable Solids

Date 1956 July	ml/liter Raw	Imhoff	Filter
2	5	1.5	3.5
3	11	0.2	0.4
4	14	2	0.5
5 (A)	11	0.1 less than	0.5
7	13	0.7	less than 0.1
8	20	0.5	less than 0.1
9	18	less than 0.1	less than 0.1
11 (B)	18	0.4	less than 0.1
12	22	0.2	less than 0.1
13	14	1.5	1.5
14	14	0.5	less than 0.1
15	20	less than 0.1	less than 0.1
16 (B)	12	less than 0.1	less than 0.1

(A) - 13 Hour Composite
(B) - 24 Hour Composite

CHEMICAL ANALYSIS OF FINISHED WATER
MAMMOTH CAVE NATIONAL PARK

The chemical analysis of the water obtained from the U. S. Geological Survey, Circular #341, is as follows:

Population Served: 2,000
Ownership: United States Government.
Source: Two springs.

Spring 8600-3710-1. 1.1 miles northeast of Mammoth Cave Post Office.
Water-bearing strata, Chester Group; estimated minimum flow, 25 gpm.
Spring 8600-3710-2. 1.5 miles northeast of Mammoth Cave Post Office.
Water-bearing strata, Chester Group; estimated minimum flow, 10 gpm.

Treatment: Chlorinated to disinfect water. Treatment plant located adjacent to each spring.
Rated capacity of treatment plant: Unknown.
Storage: 200,000 gallon concrete surface reservoirs located near each spring.
Total distribution of water for 1951: 9,000,000 gallons.
Average daily pumpage, 1951: 24,000 gallons.

Analysis, in parts per million, spring 8600-3710-1.
(Collected June 20, 1951)

Silica (SiO_2)	9.8
Iron (Fe)	.16
Manganese (Mn)	-
Calcium (Ca)	24
Magnesium (Mg)	1.9
Sodium (Na)	1.5
Potassium (K)	1.5
Bicarbonate (HCO_3)	84
Sulfate (SO_4)	1.6
Chloride (Cl)	1.2
Fluoride (F)	.0
Nitrate (NO_3)	.6
Dissolved Solids	83
Hardness as $CaCO_3$	
Total	68
Noncarbonate	0
Temperature (°F)	58
pH	7.6
Specific conductance at 25°C (micromhos)	145

During the survey, a sample of finished water was analyzed for pH, Chloride, and Alkalinity, and gave comparable results to the above analysis.